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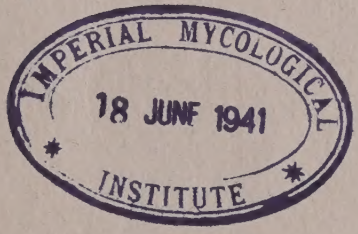

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VOL. 7, No. 1 MARCH, 1941

A Neglected Opportunity

By

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At the September meeting of the South Australian Branch of the A.I.A.S., a discussion on the " Organisation of Agriculture "* was introduced by four speakers. In the general discussion which followed considerable interest was shown in questions which belong properly to the field of rural sociology. This branch of agricultural science is largely neglected in Australia at present ; yet if our agriculture is to weather the storm which will follow the war, politicians and their advisers will need to be armed with a sound body of knowledge in this field. Scientific research is the only inexpensive way of building up such a body of knowledge. This article has been compiled from the notes prepared by the author for the meeting mentioned above.

The prices of agricultural commodities are being influenced by two long-term trends in the human environment. These are the steady improvement in the technical efficiency of agriculture and the trend towards stationary or declining populations in most countries of the Western World. The influence of these fundamental trends can be expected to transcend the temporary effects of war, blockade and post-war revival.

The wholesale price of wheat is interesting in this connection (see Fig. 1). It is difficult (and quite outside the scope of this essay) to disentangle all the factors at work, but there is clearly a suggestion that the high prices ruling between 1915 and 1928 were merely a temporary phenomenon.

* See report this *Journal*, 6 : 215, 1940.

The trend towards increased agricultural efficiency can be detected throughout the world, although it is, at the moment, being deliberately held up in some countries for political reasons. There are some instructive figures for the U.S.A. which were prepared by the Department of Agriculture.[1] The average worker on farms produced 150 per cent. more in 1930 than in 1870. During the 60-year period, the output per worker increased 2·5 per cent. per annum. If this improvement were maintained, a farm population equal to that of 1930 would produce 62·5 per cent. more in 1960 than in 1930. Alternatively, the same volume of goods could be produced by 61 per cent. of the population. It is pointed out by Goodrich *et al.*[2] that most students of the subject expect far greater increases in efficiency than this unless they are prevented by bad statesmanship.

There is little need to elaborate here the trend towards stationary or declining populations. It has been detected in every industrial country of the world with the possible exception of Russia.

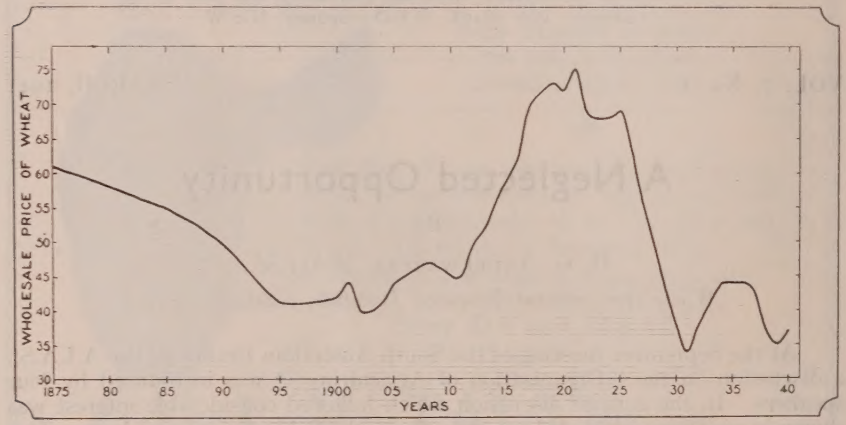

Figure 1.
Showing the wholesale price of wheat at Australian export ports.

There will not be any great increase in the number of people in the Western World who need to be fed and clothed* ; but there is likely to be an increasingly efficient home agriculture to feed them. Clearly the prices of agricultural products are not likely to rise. If Australia is to continue to compete on world markets we must either accept a lower standard of living or increase the efficiency of our agriculture.

In the search for efficiency it is not sufficient to consider only technology and economics ; the social organisation of the rural population is important. With an unsuitable organisation much human energy, both physical and mental, may be wasted. Also efficiency may be achieved at the price of much misery for part of the population. The trend in agricultural efficiency is illustrated in Figs. 2 and 3. They are based on data from the " Statistical

* It is sometimes claimed that demands for food imports from Asia will offset this condition. But it is unlikely that the backward countries of Asia can develop an export trade quickly enough to help solve the urgent problems confronting the agricultural industries of the Western World.

Register for South Australia " and from the " Commonwealth Year Book ". The figures for farm workers are for males only. A change in the methods of collecting data about 1922 made it impossible to have a continuous record of female workers. It is likely that their exclusion has resulted in an understatement of the trend which the diagrams illustrate. For Fig. 3 the gross value of rural production was divided by the index number for wholesale prices given in the Year Book (1909–1000). The result was then divided by the number of rural workers to obtain a measure of production per worker. The data on which these figures are based are crude. Greater refinement may be achieved by treating individual industries or smaller geographic units ; and by allowing for certain climatic and economic factors. But it is considered that they serve to show broadly the general trend. There has been a fairly continuous increase in agricultural efficiency ; this doubtless was associated with improvements in farm practice resulting from the application of scientific method to technical problems. One is tempted to infer that the flattening of

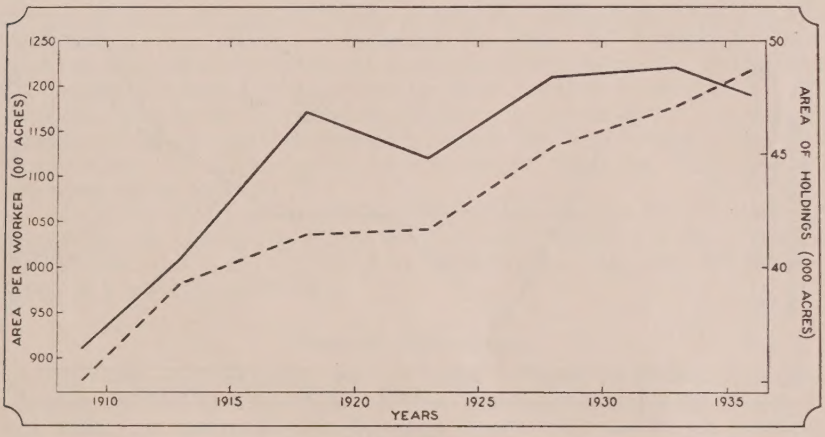

Figure 2.
Showing the area of rural holdings in South Australia (broken line) and the ratio of area of holdings to number of rural workers (complete line). (Data for area inside county boundaries.)

the curves after about 1925 may be associated with the failure to apply scientific method to the problems of social organisation in agriculture. These problems have become increasingly acute during the past decade.

Lessons from American Experience.

There are some interesting lessons to be learned from American experience. Since our two societies continue to accept as a practical working philosophy an outworn economic creed propounded by economists over 100 years ago,* it is likely that Australian farming industries will respond to the force of

* See Lloyd, " Democracy and its Rivals ", for a popular exposition of this doctrine. Briefly it states that the best way to ensure a prosperous community is to give everybody the fullest possible freedom in the pursuit of his own gains. With modern developments along the lines of inequality of opportunity, this amounts in practice to giving the *rich* every possible freedom to pursue their own gains.

economic pressure in much the same way as the Americans have done. When the full blast of the depression hit United States agriculture in 1930 the urge towards greater efficiency was met by a tremendous increase in large scale tractor farming. " Fortune "[3] tells of a big Mississippi planter who bought 22 tractors and 13 4-row cultivators, evicted no less than 130 of his 150 share-cropper families and kept only 80 day-labourers. During the years 1930-1937 the sales of farm tractors increased by no less than 90 per cent. Paul Taylor[4] studied two cotton counties of the Texas Panhandle. He reported : " Commonly the landlord purchases a tractor, throws two 160-acre farms into one operating unit and dismisses both tenants. Sometimes the ratio of displacement is even higher rising to 8, 10 or even 15 families of tenants." F. L. Allen[5] summed up the position like this : " How far would this new trend go ? Would great mechanised farm corporations, perhaps controlled from metropolitan cities, put out of business those smaller farms of those rolling

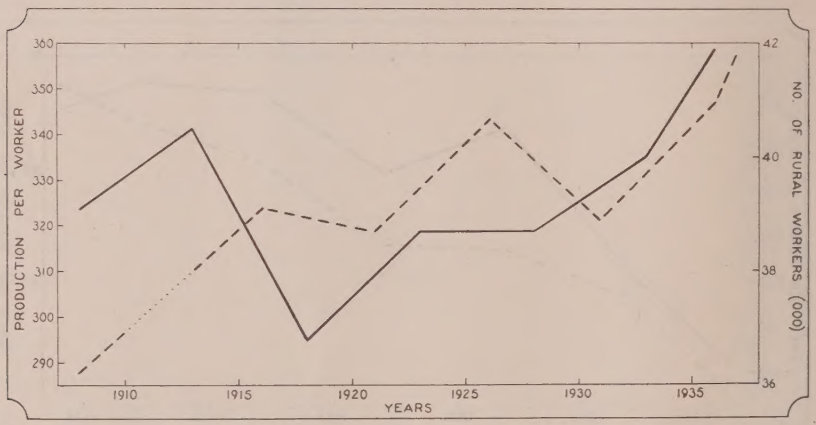

Figure 3.
Showing the number of rural workers in South Australia (complete line) and the ratio of rural production to number of workers (broken line). (Data for whole State.)

downs which abounded in the old cotton south ? What would become then, of the already miserable share croppers ? Were the other parts of the country destined sooner or later to go through the same sort of transition that was taking place in the south and west, producing a huge roving landless proletariat of the land, helpless if unorganised, menacing if organised because it had no stake in the land and its settled institutions ? These questions too, waited for answers."

He might well ask these questions, for this same trend has been carried to almost breath-taking proportions in other American industries. E. D. Kennedy[6] gives these revealing figures. In 1935 there were nearly half a million corporations in the U.S.A. Between them they earned profits of over 1,600 million dollars. But if one omitted from the reckoning 960 of the biggest, the profit turned into a deficit. In 1937 about 60 per cent. of the profits made by these 960 were made by 42 of them—and 24 per cent. by six of the biggest.

This same tendency for wealth to accumulate in the hands of few is apparent in Australian agriculture, too. If the forces of *laissez-faire* are allowed free play, it must needs continue to develop still further. It is important that students of agriculture should recognise the social evils likely to result if this tendency is carried as far as it has gone in the U.S.A.

I think there are only two alternatives. We can ignore the urge for greater efficiency and throw the weight of government action into the scales in favour of the *status quo*. At present the ratio of owners to hired labourers is about 1 : 1·2. This means that farms are largely of the " family farm " type having much in common with the peasant farms of Europe (from the sociologist's point of view, at any rate). Vigorous action by the government might well be able to retain this organisation despite the force of economic circumstances. If we took this action we should be following the precedent of many European countries which have made strenuous efforts to build up and maintain a peasant class despite the economic disadvantages because it is considered that a large and prosperous rural population represents an essential element of social stability and military strength. Also much of the New Deal legislation has been directed towards the same end. The National Resources Board in 1934 estimated that it should be possible to reduce the proportion of the population engaged in agriculture by about one-third to one-half if it were practicable to aim at the maximum economy in human labour. It was also pointed out that it would be unwise to aim at this goal so long as there is a " continuance of technological unemployment associated with technical improvement in industry."[7]

If it is true that a policy of bolstering the *status quo* can be carried through only at the cost of reducing living standards (and experience in other countries suggests that this is the case) then we should explore the other alternative—which is a planned agriculture.

Planned Agriculture.

There is much planning abroad today. Under totalitarian capitalism (Fascism and National Socialism) planning has been associated with a gigantic war effort. It has resulted in a steady concentration of wealth into fewer hands and a general depression of the living standards of the common people. These societies have given no indication that they can plan for plenty under peace conditions. Indeed many observers are convinced that they cannot.[8] Attempts at planning under democratic capitalism (including the New Deal) have so far all been restrictive in character. The most that has been attempted has been to restrict output in order to bolster up prices.[8, 9] The only place where planning aims at maximum output is Russia. In that country socialist planning does seem to be making steady progress despite the technical and political disadvantages under which it labours. Unfortunately Russian experience is not likely to help us much. Their attempt to socialise agriculture nearly broke down when it encountered the Kulaks which were a relatively small class. They were eventually liquidated at a tremendous cost in human misery. Our farmers are practically all " Kulaks ".

Clearly we shall need to work out plans to suit our own conditions. The problem is to find some way of harnessing the efficiency of large-scale farming without sacrificing the peculiar efficiency of the " family-farmer " and without producing conditions which might inspire an Australian " Grapes of Wrath ". The merits of large-scale farming include more flexibility in management and

marketing, more skilful management, closer contact with scientific extension work, and a more economical use of capital—it avoids, for example, unnecessary duplication of machinery and buildings. The peculiar merits of the " family farm " unit are largely the outcome of the personal interest which a farmer takes in his *own* block of land. Details of land, stock and pasture management are likely to receive better and more conscientious attention from an owner than from a hired labourer.

Under a rational organisation of agriculture which aims at maximum efficiency there is likely to be fewer people needed in rural industry than at present. This will be true even if it is desirable (in the light of future developments in international trade) to maintain production at its present level. But it may well happen that we shall need less agricultural goods than at present. It is likely that most of the people who may be displaced from agriculture would need to be absorbed into secondary industry, or into those " services "* for which demand is likely to be elastic. But with society organised as it is at present secondary industry is afflicted with chronic unemployment and money is lacking for adequate social services.

It would appear that some planning in secondary industry will have to be done before a fully planned agriculture is possible. A study of the problems involved may indicate that planning, on the scale required, is possible only under Socialism. If this is so, then we should study how to orientate the present trends in agriculture so that they form the first steps towards a gradual socialisation of the industry.

Whether a compromise between large-scale commercialised farming with ownership gradually drifting into the hands of financial institutions and individuals remote from the farm, and the peasant (or " family farm ") type of ownership can be worked out remains for the future to answer. The solution may be in some form of co-operative farm in which the unit for purposes of capital investment and management is large but in which a limited ownership is vested in all the people employed in the unit. Or it may be quite different. Speculation is idle unless based on sound knowledge. Unless some attempt is made to apply scientific method to the problems of the social organisation of agriculture, then any efforts which may be made to organise the industry will be based on haphazard theorising. Such methods may be very costly, as the Russian experience shows.

References.

(1) U.S.D.A. Extension Circular No. 203.
(2) Goodrich *et al.*: " Migration and Economic Opportunity." Univ. of Pennsylvania Press, 1936.
(3) Quoted by F. L. Allen in " Since Yesterday ", Hamish, Hamilton, London, 1940.
(4) P. Taylor: " Power Farming and Labour Displacement in the Cotton Belt ", U.S.D.A. Dept. Lab. and Bur. Lab. and Stat. Serial No. R737.
(5) F. L. Allen: *Loc. cit.*
(6) E. D. Kennedy: " Dividends to Pay ", Reynal and Hitchcocks, 1939.
(7) Report of the National Resources Board, U.S. Govt. Printing Office, 1934.
(8) See G. D. H. Cole, " Practical Economics ", Pelican Books No. A6, 1938.
(9) See S. K. Bailey, " President Roosevelt and his New Deal ", Fact No. 19, 1938.

(Received for publication, 15th February, 1941.)

* By " services " I mean social services and " tertiary industries " such as education, medicine, scientific research, transport, art, pleasure, entertainment, etc.

European Self-Sufficiency in Foodstuffs

By

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The drive for European self-sufficiency in foodstuffs has a twofold interest for Australians: firstly, for its bearing on the war and, secondly, for its long-term significance for Australia's agricultural policy. Many Australians probably fail to realise just how completely the idea of self-sufficiency has come to dominate the economic thought of Europe. It is often regarded as a passing mental aberration produced by Herr Hitler's feverish preparations for war, and the long-term significance it may have for Australia is overlooked.

An examination of the recent political and economic thought in Europe and its practical results gives little support to the facile and comfortable assumption that Australia can safely ignore developments there. In reviewing the subject, an outline of the ideas motivating the policy of self-sufficiency will be given in order to show that they represent forces and streams of thought that may not be dismissed offhandedly. Following this, some consideration will be given to the question that immediately arises as to what this effort for self-sufficiency costs the nations that are making it, and finally, an attempt will be made to present the position of the European countries in relation to their supply of foodstuffs, that is, the degree to which the self-sufficiency drive has been successful.

The ideas motivating this policy may perhaps be summarised under four headings:

(*a*) Economic Theories.
(*b*) War Fears.
(*c*) Emergency Relief Programmes.
(*d*) Sociological Considerations.

Economic Theories.

The theory that the wealth of a country consists in the diversity, rather than the total quantity of its production, was popularised by List. This theory gives rise to various arguments to support subsidies and protection, among which are:

(i) That infant industries need protection until they reach a stage of development when they can face competition unaided.
(ii) That home producers have a prior claim to the home market.
(iii) That exposure to competition with countries employing low paid labour will reduce standard of living for home workers to same level.
(iv) That concentration on a few lines of production will lead to stagnation and inability to turn to advantageous avenues of employment, if and when they present themselves.

Economists, speaking generally, look askance at these arguments and favour international division of labour on the basis of comparative costs, but experience has shown that this viewpoint is subject to many qualifications. The free exchange between countries, which this division presupposes, may not exist. Moreover, a monopoly position in an industry built up by one nation (on whatever original natural advantages) may make this industry attractive

to other nations. The manufacture of Australian iron and steel is an example of an enterprise that has reached a stage of high efficiency under the shelter of protection.

War Fears.

Preparation for war has been a strong motive behind the self-sufficiency drives of certain European nations. Various arguments can be put forward for thinking of war as a recurring event in international relationships. One is the theory that civilisations or races have their phases of growth and decline. Another is the idea that history shows a repeated struggle between " have " and " have not " nations. A third is the Marxian analysis of capitalistic economics ; that the exploitation of industrially undeveloped countries leads to the growth of rival imperailisms, between whom competition for markets becomes more intense until finally they tear themselves to pieces in large scale wars. A fourth is that ideological differences between nations, quite apart from purely economic ones, will lead to wars. Still another is the idea that war is the only final arbiter that human nature recognises ; this is the somewhat pessimistic view that it is difficult to educate people, or nations, to the stage where they will agree to disagree, even though they admit that killing an opponent won't convince him.

Whatever force these arguments may have, events have shown that any nation that organises its economy without some consideration of the needs of defence does risk, if not invite, grave dangers.

Emergency Relief Programmes.

Germany's difficulty in financing imports after the war, due to reparation payments and later to the drying up of foreign loans, led her to turn to substitute materials even before the depression of 1930. These tendencies to self-sufficiency were accentuated by the agricultural crisis that accompanied the depression in European countries. Arbitrary measures, as fixed home prices, restrictive measures such as compulsory pig slaughtering (in Denmark), financial enactments such as moratoria of debts, were put into effect in practically all European countries.

There were three ideas behind this policy :

(i) Alleviation of agricultural distress.
(ii) An attempt to lift the country out of the depression by restoring prosperity to agriculture.
(iii) A vision of effecting some permanent balance and stability in the country's economy.

An indication of the effectiveness of this policy in Germany is given in an article in the *International Review of Agriculture* (April, 1939), which comments on the extraordinary stability of wheat prices in Germany during a period of wide fluctuations on the world market. Wheat, in this respect, is said to be typical of farm commodities, the prices of which were fixed on a regional basis.

Sociological Considerations.

The desirability of a large agricultural population is a widely held view. Examples of this viewpoint may be seen in recent pronouncements of the French government and, implicitly, in Australian land legislation. The argument is usually advanced on grounds of preserving virility and social

stability in the population. Moreover, it is said that the independent life of the farmer develops desirable national characteristics. These theories are difficult of proof or disproof. An appeal to history is open to the objection that conditions change; for example, the spread of general education is a factor to be taken into consideration.

The arguments outlined above, taken together with the fact that during the pre-war years efforts aimed at better international relationships and freer trade between nations showed little, if any, success, would preclude any easy dismissal of the self-sufficiency policies. It seems probable that any attempt to improve trade relationships in the near future will have to start from a basis of planned internal economic organizations for the countries concerned.

Costs Involved in Self-Sufficiency.

If the policy of European self-sufficiency is accepted as a real feature of the economic life of that continent, the obvious question is, what is this self-sufficiency costing?

This is difficult to assess. From the national viewpoint, one or two general indications may be given. Geoffrey Crowther, editor of *The Economist*, in "The Sinews of War", states that, approximately, in Britain it takes $6\frac{2}{3}$ men's work to feed 100 consumers, while in Germany it takes 14. Secondly, Dr. Schacht at the conference of agricultural economists in Berlin in 1934, stated that the policy of making and using substitute materials was economically harmful to Germany. And, thirdly, from the *International Review of Agriculture*, prices for wheat in the various European countries at the end of 1938 or during 1939 were taken. Using the rates of exchange quoted in the same journal for the time at which the price was given, the following figures in Australian currency were obtained:

Denmark	4/3	per bushel
Hungary	6/6	,, ,,
Germany	13/-	,, ,,
Poland	6/6	,, ,,
France	8/5	,, ,,
Italy	11/8	,, ,,
Netherlands	9/-	,, ,,
Sweden	6/2	,, ,,

It seems certain that most of these countries could have purchased wheat cheaper than the home prices quoted above, if they were willing and able to pay for it.

These facts would seem to suggest, if they do not prove, that in so far as the European nations deliberately and freely chose the policy of self-sufficiency, they committed themselves to some sacrifice in total economic well-being.

Has Self-Sufficiency Proved Successful?

The final part of this brief survey—the attempt to ascertain the success that has attended this self-sufficiency drive—was rendered very difficult by the lack of relevant statistical material. The final sources proved to be *The Statistical Yearbook of the League of Nations* and *Foodstuffs and Raw Materials* (1939) published by the Economic Intelligence Service of the League of Nations. In both of these publications the incompleteness of the statistics provided by the various countries is emphasised by the editors, and the figures given here are advanced with the realisation and the warning that they are no more

accurate than the material on which they are based. The cereal figures were checked as closely as possible against Broomhall's *Corn Trade News*, and it may be noted that the general conclusions reached agree very closely with those given by Professor Karl Brandt in an article in *Foreign Affairs* and with those stated by Sir William Beveridge in his pamphlet *Blockade and the Civilian Population*.

The broad general conclusions, arising from a survey of the available statistics, are that Europe is substantially self-sufficient in foodstuffs, with the following main exceptions:

(*a*) Six to ten million tons of grain mainly for animal feedstuffs.
(*b*) Protein concentrate in $4\frac{3}{4}$ million tons of oil seeds.
(*c*) Fats in these imported oil seeds.
(*d*) Phosphates, necessary for food production.

The production and import figures for some of the main foodstuffs, calculated from the statistics consulted, are given below. It should be noted that observers agreed that a large percentage of the bread grains imported into Germany during the years quoted below was for storage rather than immediate consumption.

EUROPEAN PRODUCTION AND IMPORTS OF FOODSTUFFS.
Cereals (million tons) (excluding Russia).

	1939.	1938.	1937.	1936.
Production	119	129	117	114
Imports	—	11	12	8

Of these imports, wheat and maize usually constituted over 80 per cent. in about equal proportions.

Other Foodstuffs (excluding Russia).

	Production.	*Imports.*
Oils and oil seeds (1938)	.. 2,046,600 metric tons.	$4\frac{3}{4}$ m. tons (1935).
Butter (1937)	1,310,300 metric tons.	190,000 tons exports, 1935.
Milk (1937)	944 million hectolitres = 100 million tons.	—
Margarine (1937)	810,900 metric tons.	—
Fish (average)	3,000,000 metric tons.	—
Meat (1937) except Yugoslavia	9,000,000 metric tons.	250,000 m. tons (exports, 1935).
Potatoes (1936–38)	150,000,000 tons.	—
Sugar (1937–38)	5,500,000 tons (beet). 100,000 tons (cane).	—
Phosphates (natural)	.. 100,000 tons.	4,000,000 tons.

If it is desired to draw conclusions from this situation, the following broad generalisations may be made:

(*a*) That insofar as the blockade is likely to affect the food supply of the European population, it will be through the disruptive effects of the war rather than by the interruption of necessary imports.

(*b*) That after the war Australia will find a considerable market for her surplus agricultural products in Europe only if any potential demand existing there now can be converted to an effective one.

(*c*) That Germany's technological advances in agriculture may well contain valuable lessons for Australia.

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Rotary Cultivation in Australia

By

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Rotary cultivation is a phrase used to describe a particular kind of cultivating machine, namely an automotive that employs cultivating tynes or blades on a rotating shaft independently driven from the engine. In this way the earth is cut and moved by the power-driven tynes, not by a tool that is dragged through the soil.

Such an idea came to light in the days of steam ploughing when steam traction engines were used to drag multi-furrow ploughs, usually by cable, thus simply substituting steam for horses in a large way. But it was imagined by some that the power of steam could be better applied to the land in the manner in which steam power was universally used, namely by a rotary motion of tools in the soil, instead of converting the rotary motion of steam engines into linear motion, and thus dragging an inert tool through the soil.

Early English attempts using steam engines failed because the traction engines were so cumbersome and heavy, and the resulting tilth was not accepted as satisfactory. The development of the internal combustion engine has solved the first problem, so that the idea has been revived in the form of two or three modern tractor types of rotary tool. As to the second problem, the tilth produced, it is believed by the protagonists for the method that that has been solved too ; at any rate they are more confident that the tilth now obtainable will not be quickly rejected, because they know, and most agricultural and soil scientists know, that the criteria of good tilth and good cultivation are not stated as dogmatically now as they used to be.

Types of Rotary Cultivating Tools.

It seems unlikely that there are more than two geometrical possibilities for digging the soil with tynes or blades attached to a rotating shaft, namely :

(*a*) Vertical tynes on the underside of a flat disc rotating on a vertical or nearly vertical axis attached to the back of the tractor. Such tynes have a circular motion in plan ; when carried (one might say dragged) forward by the tractor the soil is stirred for the depth of the tynes and the width of the disc. Different degrees of mixing and breaking up can be obtained by suitable selection of tyne shape and aspect of the drive axis. An example of this type is the " Gyrotiller ", a crawler tractor of large size made by Fowler's of England ; it is looked upon as a deep tilling tool, and it is so large that it is only economical when used on contract work. Experiments on the results of its work have been carried out at Rothamsted.[1, 2]

(*b*) A horizontal transverse axis or shaft across the back of the tractor, with radial tynes or blades attached. Rotation of the shaft causes the tynes to chop away clods of soil, and to break them up. Various examples of this type are in use in England today, where they are known generally as " Rototillers ". Keen and Staff at Rothamsted have carried out a number of experiments on cultivation with this type.[3, 6] The only rotary cultivation implement made and used in Australia—the Howard Rotary Hoe—is of this type.

In a rapid survey of the literature no record has been found where either of these types of implement has been used or tried in North America ; the

only references are to occasional reports of American agricultural engineers who had seen the implements in England and Europe. What is known in the United States of America as a " rotary hoe " is a very light hoeing or harrowing tool, with prongs on a transverse shaft rotated by the wheels of the implement.

History of the Australian Machine.

The application of this cultivating principle was first attempted in Australia by Mr. A. C. Howard, himself the son of an Australian wheat farmer, at Moss Vale in 1923. The first machine consisted of five rotor sections, each three feet wide and each driven through universal joints from an engine mounted in a long chassis. Although several of this early type were sold, the machine was obviously cumbersome and inconvenient ; it may be supposed that this attempt started where the earlier English attempts stopped, except that an internal combustion engine was used instead of steam power.

Howard then got much better results by attaching a rotary element (four or five feet wide) to the Fordson tractor, which in the later 1920's was becoming very popular. When supplies of these tractors shortened (they went off the market in 1933-34 in changing from Canadian to Irish and to English manufacture), Howard developed several independent smaller machines on two or three wheels powered by small petrol motors ; and then went on to making complete four-cylinder tractor units, now known as the D.H.22. These are entirely made at the Northmead factory of Howard Auto-cultivators Ltd., except for such component parts as are not at present made in Australia, e.g. magnetos and ball races. It is interesting to note that Howard has taken the machine and its patents to England[8].

Mechanics of the Transverse Axis Type.

The following notes relate particularly to the Howard tractor model :

(*a*) *The tractor* is an orthodox four-wheel tractor with a four-cylinder kerosene engine ; it can be equipped with steel or pneumatic wheels. A comparison between it and the English Fordson tractor now on the Australian market is shown in Table I.

TABLE I.
Comparison of Howard and Fordson Tractors.

	Howard D.H.22.	Fordson.
Weight of tractor	2600 lbs.	3400 lbs.
,, ,, ,, with hoe	3300 lbs.	——
Length of wheel base	5 ft. 0 in.	5 ft. 3½ ins.
Height (main wheel diam.)	3 ft. on rim	3 ft. 6 ins.
Engine (max. b.h.p.)	28	27 on belt (1938) now up to 30
,, (speed, r.p.m.)	1350	1100
Speeds (miles/hr.)	5 speeds [1] 0·7 to 3·2	3 speeds [2] 1·7, 2·5, 4·3
Selling price, 1940—		
(*a*) Tractor alone, steel wheels	£312	£270
(*b*) With hoe attached — — —	£436 [3]	£400 [4]

Notes.—[1] Overdrive gear can be fitted giving five more speeds up to 15 m.p.h.
[2] Special ploughing speed of 3·1 m.p.h. can be fitted.
[3] Includes hydraulic hoist for raising hoe, costing £25.
[4] Not including hydraulic hoist.

(*b*) *The hoe* consists of a milling shaft fitted with fixed discs or flanges equally spaced ; to these discs are attached the cultivating blades. Though different shapes of blades may be used, they are usually L-shaped, the body of the L being attached to the disc, and the transverse leg of the L cutting the bed of the sod. The general arrangement of shaft and blades is shown in

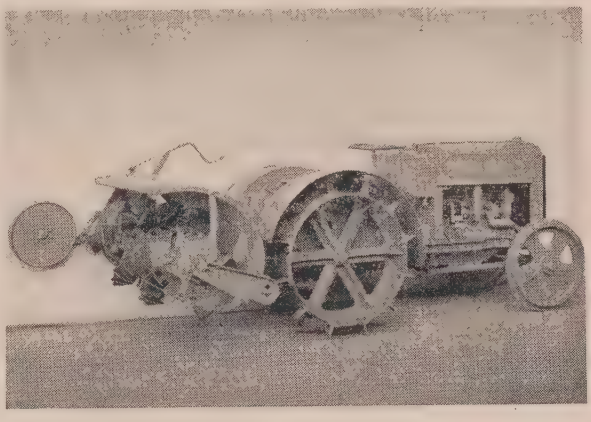

Figure 1.

Howard "Twenty-two" Tractor and Rotary Hoe (standard field model with steel wheels).

(*Block by courtesy of Howard Auto Cultivators Ltd*)

Figs. 1 and 2, ; it will be seen that three like blades are fitted on one side of each disc, the blade axes being 120° apart. There are also three oppositely curved blades attached to the other side of each disc, making six to a disc ; the blades on any one disc are staggered relative to those on adjacent discs. In a 5 ft. shaft there are 30 blades : 6 on each of four discs and 3 on each of the two end flanges. The milling shaft is driven from the tractor engine through the power take-off, at constant speeds independent of the forward speed of the tractor.

In all machines of this transverse axis type, the milling shaft rotates in the same sense as the tractor wheels. This means that the reaction of the soil to the blades tends to cause the tractor to move forward. This is claimed to

Figure 2.

Howard Rotary Hoe. 5ft. model, showing arrangement of blades.

Note that all blades do not enter the ground simultaneously.

(*Block by courtesy of Howard Auto Cultivators, Ltd.*)

be the fundamental feature of the device which gives it considerable mechanical advantages over the orthodox draft implements : the tool helps the tractor.

(*c*) *Power requirements.* The economy of this method in ploughing effort is difficult to estimate. While, in principle, it is quite easy to measure the pull

of a drawn plough, and to estimate the energy required, say in h.p.hrs., to plough an acre of a given soil to a given depth, it is no easy matter to measure the effort required to cultivate with a rotary tool, since it is difficult to measure the amount of power absorbed by the tool as distinct from that absorbed by the tractor. So far as I know, no tests have been made on this point, though I think it is a matter worth resolving.

Nevertheless, current opinion of users tends to the belief that one pass or stroke with the rotary hoe requires less effort than one pass with a plough, either disc or mouldboard, and that difficult country can be more easily tackled than by other ploughing implements.

(*d*) *Action of the blades.* The milling shaft is designed to rotate at a usual speed of 127 r.p.m., but alterations can be made to give additional speeds of

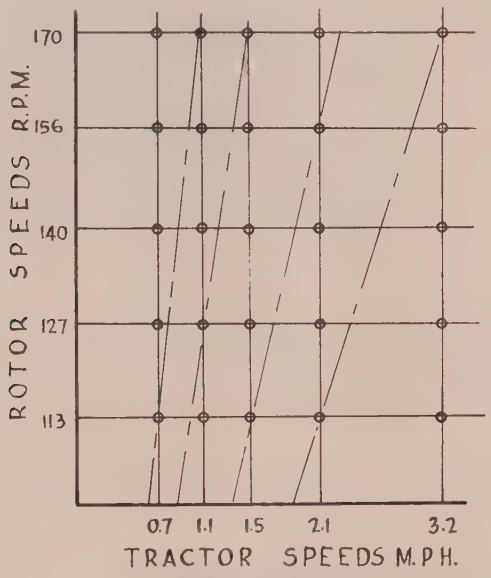

Figure 3.

113, 141, 156, 170 r.p.m. These speeds are independent of the tractor speed, so that any combination of tractor and rotor speeds can be chosen. These combinations are represented by the intersections in Fig. 3.

Since the radius of rotation of the cutting edge is 12 ins. and the average effective radius of the tractor drive wheel is roughly 20 ins. ; and since, for most practical purposes, the tractor wheel may be thought of as rolling on a plane surface, then the path traced out by a point on the cutting edge is a modified trochoid, represented in Fig. 4 for a tractor speed of 1·5 m.p.h. and rotor speed of 127 r.p.m.

Since there are three like blades to each disc on the milling shaft, the paths followed by all three constitute the cutting and working of the soil. A sod that has been cut out by one blade runs the risk of being cut by the path of the next blade, or by several such paths ; so that theoretically and in fact

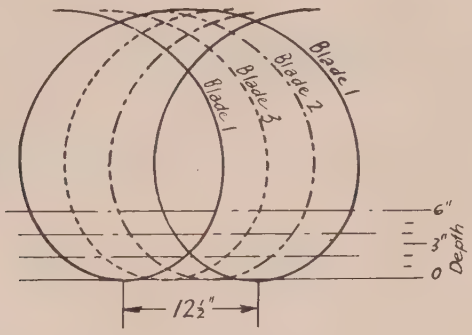

Figure 4.
Paths of Blades.—Rotor speed 127 r.p.m., Tractor speed 1·5 m.p.h.

sods can be cut to more or less any desired degree by suitable choice of rotor speed in relation to tractor speed. It should be noted that combinations of rotor speed and tractor speed that lie on a straight line through the origin of the graph in Fig. 3 have similar blade actions relative to the soil.

The sole or bed of the ploughing is therefore a series of crests and hollows running *across* the track ; in disc ploughing a similar series of crests and hollows runs *along* the track. The accompanying table shows the distance between the crests, which is equal to the distance between the successive blade positions as the tractor moves forward, for standard rotor speed of 127 r.p.m. and various tractor speeds.

TABLE II.
Blade Action at Rotor Speed 127 r.p.m., Various Tractor Speeds.

Tractor speed, m.p.h. ..	0·7	1·1	1·5	2·1	3·2
Drive wheel, r.p.m. ..	6	9·3	13	18	27
Rotor, r.p.m.	127	127	127	127	127
Ratio of speeds	0·05	0·075	0·10	0·14	0·21
Drive wheel dist. per revolution of rotor	6 ins.	9½	12½	17½	26
Dist. between successive blade positions	2 ins.	3·2	4·2	6	9
Depths, hollows and crests	—	under ¼ in.	¼ in.	1 in.	2½ in.

Besides mouldboard and disc ploughing and various forms of tyne cultivation, here is another answer to the problem of constructing a seed bed, or the base to a seed bed ; it is for the agricultural scientist to say, if he can, whether it is an acceptable answer.

Quality of Tillage of the Transverse Shaft Rotary Hoe.

(*a*) *Comminution and Tilth.* It is to be expected that vigorous blade action like that described would divide the soil thoroughly and finely, and it is generally assumed that a fine tilth is produced. Experiments conducted at Rothamsted,[3, 4, 5, 7] however, show that the tilth is not substantially finer than that produced by other methods of cultivation, but that it is much more " fluffy " or loose. This looseness of tilth is due to aeration of the soil arising

from the energetic cutting and mixing and its falling back into place after being chopped and lifted. After the treated soil has been well wetted with rain, the fluffiness and the unusual aeration disappear with the settling or consolidation of the soil; this may lead to the formation of a hard cap wihch is a disadvantage.[3]

The following table derived from graphs submitted by Keen[4, 5] shows the kind of tilth obtained by this method compared with other methods of cultivation. No tests have been carried out in Australia on this point.

TABLE III.

Percentage Disintegration by Sieving Tests.

1926—after good winter.			Sizes of Soil Groups.	1928—after bad winter.			
Before Cultivation.	Ridging Plough.	Rotary Cultivation.		Before Cultivation.	Ridging Plough.	Rotary Cultivation.	Rotary and Ridging.
%	%	%	(Inches.)	%	%	%	%
11	6	2	1·5 and over	60	30	49	16
30	21	22	1·5—0·5	12	18	13	20
18	16	18	0·5—0·25	12	20	14	24
24	25	27	0·25—0·1	7	13	11	18
17	32	31	0·1 and below	9	19	13	22

(*b*) *Influence on Yield.* The early Rothamsted experiments[3] showed the influence of this cultivation method on the yield of various crops over four seasons. The conclusions may be summarised as follows:

(i) Rotary cultivation gave earlier and better germination of seed, followed by better early growth.

(ii) The final yield was either no better or else significantly below that obtained from plots cultivated in the usual way.

Russell and Keen, continuing these tests,[6] reported that no harmful results of using the "Rototiller" year after year had yet come to light, provided it was worked to about eight inches (at any rate on the soils on which the experiments were carried out); though they stated that deterioration of yield sometimes set in, possibly due to the increased weediness of the non-ploughed plots. (See (*c*) below.)

The general view now held overseas is that the final yield is not appreciably different from that obtained by other methods. Nevertheless, no yield trials have been reported in Australia.

(*c*) *Influence on Weeds.* In the later Rothamsted experiments, Russell and Mehta[7] showed that "rototilled" plots tended to be more weedy than plots that were ploughed, "due partly to the inability of the rotary tool to bury the more troublesome perennial weeds, and partly to its leaving more weed seeds in the surface layer". The experimenters go on to say: "This effect is usually unimportant when this implement has been used for one year only; but tends to become more troublesome if used for several years in succession".[7] No tests on this point have been carried out in Australia. In any event, since there are few perennial weeds in Australia compared with England, the problem may not arise.

General Properties of the Rotary Hoe.

Conclusions, some from general experience and some from measured trials (though not in this country), show that the general properties of rotary cultivation by the transverse milling shaft method—for example, the Australian Howard Rotary Hoe—are :

(*a*) The use of an implement that is generally obtained attached to its specific tractor, the tractor model costing in all over £430.

(*b*) Cultivation of the soil at less effort and less cost per square inch of cut cross section, or per acre at a given depth ; and cultivation and breaking down of more difficult country than would usually be attempted by any other single tillage implement.

(*c*) Production of a tilth suitable for a seed bed in one operation, whereas with disc or mouldboard ploughing much time and one or more operations with other implements are required to produce what is usually accepted as a seed bed tilth.

(*d*) The tilth of the resulting seed bed appears (on English experiments) to be satisfactory ; but the subsequent consolidation, especially if it leads to capping, may be a disadvantage.

(*e*) The final yield is probably not appreciably different from that obtained by other cultivation methods, though the yield of weeds may possibly be greater too.

If these are the properties of the rotary hoe, and if we believe, as Keen and Staff say,[3] that " the meteorological factors exercise a predominating influence on the physical condition of the soil ; the influence of the implement is secondary " ; or with Russell and Mehta[7] that " on the whole, crop yields are surprisingly insensitive to cultivation ", then we should ask ourselves what is the proper place of such an implement as this in the field work and economy of Australian primary production.

Applications to Australian Farming Practice.

(*a*) In the first place, this combination of rotary tillage tool and power unit is a correct answer to the general problem of initial breaking up of difficult virgin country : country that is difficult as a result of heavy undergrowth, e.g. heavy native grasses, reeds, and ti-tree ; or through having a particularly hard soil, e.g. many of the Australian podsolised soils such as the majority of the grazing lands of the Western District of Victoria. Many soils in this condition are at present noted by the Institute's Potentialities Survey Group as " difficult soils ". While they may not be economically cultivable by traditional methods, they can be cultivated by the milling shaft method, so that the potentialities of a considerable area of country in Australia may be greatly increased by using such a cultivation method as this.

The merit lies not only in the fact that these heavy conditions can be overcome successfully by the rotary method, but that they can be overcome relatively cheaply, since the soil requires much less subsequent treatment with other breaking down tools before a crop or a pasture can be sown down.

(*b*) Apart from the ability to cultivate difficult soils, one of the significant features of the rotary method is that just mentioned, and quoted in (*c*) above,

namely that in general a suitable tilth for seeding can be produced in one operation. Where a bare fallow period of some months is the approved practice, little is to be gained in producing such a tilth in the initial cultivation, and in the later workings the use of the rotary hoe can rarely be justified as against the lighter implements. Under these conditions, then, represented by the bulk of the wheat belt of Australia, it is doubtful whether there is a place for the rotary hoe in ordinary wheatland cultivation.

Where, however, fallowing is not standard practice, as in the southern districts of Victoria, or after leguminous pasture, the production of a satisfactory tilth for immediate seeding in one operation has a decided economic advantage.

Notwithstanding that the greater part of the cereal growing areas in Australia follow the fallowing system, the areas on which fallow farming is not necessary (and therefore the areas on which rotary cultivation can be practised to give a seed-bed tilth directly) are appreciable. As to clover ley farming, the significance of this is coming to be appreciated and the method practised more widely throughout the country.[9] In both these instances economy of effort and of cost could be gained through the use of the rotary hoe.

Furthermore, for the establishment of small-seeded pasture species, the fine state of tilth required can be more effectively obtained with the use of this tool than by any other method in one operation. Also such a tilth, whether for pasture or cereal sowing, can be obtained with the rotary hoe with relatively shallow cultivation, whereas ploughing is customarily done to greater depths, the sods being eventually broken down by other machines to the desired tilth. This represents an economy of cultivation effort in favour of the rotary method, over and above the fact that the tilth may be obtained in one operation.

(*c*) Incidental uses, not obtainable with other cultivating tools are :

(i) Eradication of certain types of weed that do not grow again from their finely chopped roots. No other cultivating tool cuts the roots so drastically.

(ii) Demolition of rabbit warrens ; very deep cultivation may be got in the tractor model by removing the depth control wheel from the milling shaft.

(iii) Loosening soil for earthworks, e.g. channel digging, and construction of banks and levees. Not only is the soil effectively loosened from the bed or subgrade, but it is in a much better condition for shifting, and replacing and consolidating in banks than after loosening by ploughing.

(*d*) Self-contained machines embodying this rotary principle enjoy much greater flexibility of movement than ploughs of the same width. This gives a particular advantage to the small rotary hoe in cultivating round fixed obstacles and in confined spaces, such as in orchards, vineyards and garden plots. Many believe that here, rather than in the broad acres, is the proper place for the rotary cultivator type of machine.

Nevertheless, from the foregoing it is submitted that, while not a revolutionary introduction, the rotary hoe has a definite place in Australian farming practice. Probably its greatest contribution is in the greater latitude of soil

and climatic conditions under which a satisfactory tilth may be produced, so permitting seasonal operations to be completed in time, with considerably less dependence on weather conditions.

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The Analysis of Quasi-Factorial Designs with Incomplete Data

2. LATTICE SQUARES

By

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The analysis of experimental data derived from balanced incomplete block designs, the internal structure of which has been impaired by the loss, or unreliability, of the observations contained in a block or treatment, has been described in a previous paper in this Journal.(1) The present paper is concerned with the analysis of quasi-Latin square designs (lattice squares),(3) (4) which have also been impaired by the loss of complete sets of experimental values, e.g. a row (or column) or a treatment.

Structure of Lattice Squares.

In the lattice square designs, the quasi-factorial principle has been extended in order to allow for the simultaneous elimination from the treatment comparisons, of differences associated with two different groupings of the experimental material, as in the ordinary Latin square.

The number of treatments or varieties must be a perfect square. If the number of varieties is, say p^2, it is possible, for certain values of p(2), to divide the varieties into $(p+1)$ orthogonal groups of p sets, each set containing p varieties, i.e. in such a way that each set of any given group of sets contains only one variety from each set of any other group of sets. Each complete replication of the varieties is arranged in the field in the form of a square, of which the rows correspond to one group of sets and the columns to a second, thus confounding the varietal comparisons corresponding to two groups of sets with row and column differences in each replication.

If p is odd, balance can be attained with a minimum of $\frac{1}{2}(p+1)$ replications but, if p is even, each group of sets must be included twice, giving $(p+1)$ replications and squares.

In the analysis of these designs it is first necessary to calculate for each variety a quantity, (pQ), defined as p times the variety total less the totals of each row and column in which that variety occurs. The computation of the sum of squares ascribable to varieties is the only new feature of the analysis of variance, since items for lattice squares, rows and columns are determined in the ordinary manner. When p is odd, the sum of squares for varieties is

$$\frac{2}{p^2(p-1)} \; S\{(pQ)-(\bar{pQ})\}^2$$

and the adjusted varietal means are given by

$$\frac{2}{p(p-1)}(pQ)+\frac{2p}{p^2-1}\times\text{general mean.}$$

The estimated variance of the difference between any two adjusted means is

$$\frac{4}{p-1}\times\text{estimated variance of a single plot.}$$

If p is even, all constant multipliers in the above expressions, except the factor $2p/(p-1)$, must be divided by 2.

In the analysis given below, only the case when p is odd has been considered in detail. When p is even, the analysis, though somewhat more complex, follows similar lines.

Missing Treatment.

Without loss of generality it may be assumed that the replicates of variety 1 are missing from the first row and first column of each square, and further, that in the first square variety 1 is associated with varieties 2, 3, ..., p in row 1, and with varieties $p+1$, $2p+1$, ..., p^2-p+1 in column 1. The set of constants which has to be determined is as follows:

general mean	: m	
lattice squares	: l_i	$S(l_i)=0 \quad i=1, 2, \ldots, \frac{1}{2}(p+1)$
rows	: r_{ij}, for a given value of i	$S(r_{ij})=0$
columns	: c_{ik}, for a given value of i	$S(c_{ik})=0$ } $j, k=1, 2, \ldots, p$
varieties	: v_t	$S(v_t)=0 \quad t=2, 3, \ldots, p^2$

If G is the grand total of existing observations and L, R, C and V stand for the totals of lattice squares, rows, columns and varieties, respectively, the normal equations are

$$\begin{aligned}
\tfrac{1}{2}(p+1)(p^2-1)m-S(r_{i1}+c_{i1}) &= G,\\
(p^2-1)(m+l_i)-(r_{i1}+c_{i1}) &= L_i,\\
(p-1)(m+r_{i1})+(p-1)l_i-c_{i1}+S(v) &= R_{i1},\\
p(m+r_{i2})+pl_i+S(v) &= R_{i2},\\
&\ldots\\
(p-1)(m+c_{i1})+(p-1)l_i-r_{i1}+S(v) &= C_{i1},\\
p(m+c_{i2})+pl_i+S(v) &= C_{i2},\\
&\ldots\\
\tfrac{1}{2}(p+1)(m+v_t)+S(r+c) &= V_t.
\end{aligned}$$

In any r or c equation the summation is taken over the varieties contained in the row or column concerned, while in any v equation, it is taken over the rows and columns in which replicates of the particular variety occur.

The value of m is calculated from the relation

$$\tfrac{1}{2}p(p-1)(p^2-1)m=(p-2)G+S(R_{i1}+C_{i1}).$$

The equations in the v of varieties associated with the missing variety in row 1 and column 1 of the first square reduce to

$$\left.\begin{aligned} Av_2+B(v_3+\ldots\ldots+v_p+v_{p+1}+\ldots\ldots+v_{p^2-p+1}) &= Q'_2,\\ Bv_2+Av_3+B(v_4+\ldots+v_p+v_{p+1}+\ldots\ldots+v_{p^2-p+1}) &= Q'_3,\\ \cdots\cdots\cdots\

Varietal comparisons are not all of the same accuracy ; when all replicates of one variety are missing, the types of comparison with their variances are :

(i) between varieties associated with the missing variety in any given square : variance $4\sigma^2/(p-1)$,

(ii) between varieties associated with the missing variety in different squares : variance $\frac{4\sigma^2}{p-1}\left\{1+\frac{2}{(p+1)(p^2-4p+3)}\right\}$.

Example 1.

Yates[2] has given an example showing the analysis of a balanced set of quasi-Latin squares involving 25 varieties ($p=5$). Table I shows the yields and the totals of rows, columns and lattice squares. Assume that variety 1 is missing. The normal equations are then

$$72m-r_{14}-c_{12}-r_{25}-c_{21}-r_{34}-c_{31}=1147,$$
$$24(m+l_1)-r_{14}-c_{12}=196,$$
$$\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot$$
$$5(m+r_{11})+5l_1+v_{21}+v_{22}+v_{23}+v_{24}+v_{25}=2,$$
$$\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot$$
$$5(m+c_{11})+5l_1+v_3+v_8+v_{13}+v_{18}+v_{23}=-30,$$
$$\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot$$
$$3(m+v_2)+r_{14}+c_{14}+r_{24}+c_{23}+r_{33}+c_{32}=48,$$
$$\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot$$

In Table II, the variety totals, V, the values of $-24(5Q)$ and the v are given in sets as they occur together in the rows and columns containing the missing variety.

TABLE I.

Yields (less 100) and Arrangement of Varieties.

Square 1							r
	(23) −13	(21) 3	(25) −4	(22) 3	(24) 13	2	−10·5250
	(8) −5	(6) 6	(10) 19	(7) 4	(9) 20	44	1·9750
	(18) 11	(16) 10	(20) 9	(17) −1	(19) 40	69	0·6750
	(3) −21	(1) 12	(5) −1	(2) 15	(4) 29	34	−0·3000
	(13) −2	(11) 13	(15) 16	(12) 10	(14) 22	59	8·1750
	−30	44	39	31	124	208	
c	−15·4250	−1·2000	3·0750	−3·2250	16·7750		
Square 2							
	(25) 2	(6) 9	(14) 22	(17) 28	(3) 13	74	2·5375
	(7) −7	(18) 26	(21) 37	(4) 28	(15) 8	92	−0·8625
	(19) 0	(5) 16	(8) 29	(11) 19	(22) 13	77	−1·3625
	(13) −7	(24) 15	(2) 12	(10) 19	(16) 20	59	−6·9625
	(1) −2	(12) 16	(20) 27	(23) 35	(9) 25	101	6·6500
	−14	82	127	129	79	403	
c	−19·7500	−0·0625	8·0375	11·7375	0·0375		
Square 3							
	(10) −2	(19) 38	(3) 32	(21) 37	(12) 38	143	5·3875
	(22) 3	(6) 18	(20) 21	(13) 19	(4) 15	76	−5·9125
	(18) −3	(2) 21	(11) 4	(9) 10	(25) 17	49	−13·7125
	(1) 19	(15) 19	(24) 29	(17) 32	(8) 29	128	0·8500
	(14) 8	(23) 31	(7) 48	(5) 30	(16) 52	169	13·3875
	25	127	134	128	151	565	
c	−22·9500	2·9875	8·6875	4·1875	7·0875		

Varieties are indicated by the numbers in parentheses.

TABLE II.

Variety.	V	$-24(5Q)$	v	Variety	V	$-24(5Q)$	v
2	48	4200	4·9708	6	33	6480	−4·5292
3	24	7248	−7·7292	11	36	7200	−7·5292
4	72	5616	−0·9292	16	82	3576	7·5708
5	45	7008	−6·7292	21	77	3336	8·5708
	189		−10·4168		228		4·0832
9	55	6048	−2·3917	7	45	5592	−0·4917
12	64	5976	−2·0917	13	10	5520	−0·1917
20	57	6312	−3·4917	19	78	3312	9·0083
23	53	5640	−0·6917	25	15	5472	0·0083
	229		−8·6668		148		8·3332
8	53	5112	1·8583	10	36	5760	−0·8417
15	43	6960	−5·8417	14	52	7176	−6·7417
17	59	5880	−1·3417	18	34	2352	13·3583
24	57	5400	0·6583	22	19	4224	5·5583
	212		−4·6668		141		11·3332

Now $G=1147$ and the total of rows and columns containing the missing variety is

$$22+32+103-12+109+6=260,$$

so that,

$$m=\frac{1}{240}(3\times 1147+260)=15\cdot 4208.$$

The next step is to determine the quantities Q'. In the expression for Q', the first term is the only one which varies over any set of $2(p-1)$ varieties. Consequently, the algebraic sum of the remaining terms need only be determined once. For the varieties associated with variety 1 in the first square this quantity is

$$-5(189+228)+11470-3701-196=5488,$$

the values of the corresponding quantities in the second and third squares being 5479 and 5458, respectively, so that, for example,

$$Q'_2=-4200+5488=1288,$$
$$Q'_7=-5592+5479=-113,$$
$$\text{and } Q'_8=-5112+5458=346.$$

The quantities a and b have the values $a=9/1920$ and $b=1/1920$ and so

$$v_2=\frac{1}{1920}(9\times 1288-1760-\ldots\ldots+2152)=4\cdot 9708, \text{ etc.}$$

The constants of the rows and columns containing the missing variety may now be determined. For example,

$$r_{14}=\frac{1}{5}(189-1147+925\cdot 25+31\cdot 25)=-0\cdot 3000$$

$$\text{and } c_{12}=\frac{1}{5}(228-1147+925\cdot 25-12\cdot 25)=-1\cdot 2000.$$

After substituting these quantities in the l equations, the values $l_1 = -7{\cdot}3166$, $l_2 = 0{\cdot}9084$ and $l_3 = 6{\cdot}4084$ are obtained. The values of the r and c are given in Table I.

The sum of squares attributable to the constants l, r, c and v is

$$8{\cdot}1042 \times 196 + \ldots . - 10{\cdot}5250 \times 2 + \ldots . - 15{\cdot}4250 \times (-30) - \ldots .$$
$$+ 4{\cdot}9708 \times 48 - \ldots . - 1147^2/72 = 13730{\cdot}28,$$

while the sum of squares due to lattice squares, rows and columns when varieties are ignored is

$$8{\cdot}0250 \times 196 + \ldots . - 7{\cdot}625 \times 2 + \ldots . - 14{\cdot}025 \times (-30) - \ldots . - 1147^2/72$$
$$= 12259{\cdot}42.$$

The analysis of variance is given in Table III.

TABLE III.
Analysis of Variance.

	Deg. Freed.	Sum Sq.	Mean Sq.
Total	71	14966·65	
Residual	22	1236·37	56·20
Constants l, r, c and v ..	49	13730·28	
Constants l, r and c (ignoring varieties)	26	12259·42	
Remainder (varieties) ..	23	1470·86	63·95

Examples of the two types of varietal comparison with their estimated standard deviations are

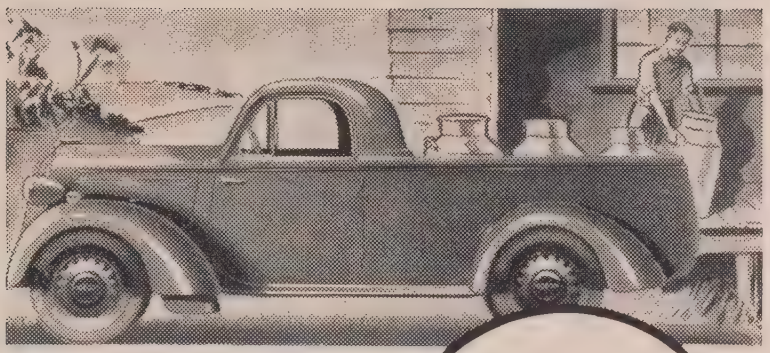
(i) $v_2 - v_3$ 12·70
$v_2 - v_6$ 9·50 $\pm 7{\cdot}50$
$v_6 - v_{11}$ 3·00

(ii) $v_2 - v_7$ $5{\cdot}46 \pm 7{\cdot}65$.

Missing Row.

Without loss of generality it may be assumed that the first row, containing varieties 1, 2, ..., p, of the first square, is missing and that the first column contains varieties 1, $p+1$, $2p+1$, ..., p^2-p+1. The normal equations are now

$$\tfrac{1}{2}p(p-1)(p+2)m - pl_1 - S(v_t) = G, \qquad t = 1, 2, \ldots, p$$
$$p(p-1)(m+l_1) - S(v_i) = L_1,$$
$$p^2(m+l_2) = L_2,$$
$$\cdot \quad \cdot \quad \cdot$$
$$p(m+r_{1i}) + pl_1 + S(v) = R_{1i}, \qquad i = 2, 3, \ldots, p$$
$$p(m+r_{2j}) + pl_2 + S(v) = R_{2j}, \qquad j = 1, 2, \ldots, p$$
$$\cdot \quad \cdot \quad \cdot \quad \cdot$$
$$(p-1)(m+c_{1k}) + (p-1)l_1 + S(v) = C_{1k}, \qquad k = 1, 2, \ldots, p$$
$$p(m+c_{2k}) + pl_2 + S(v) = C_{2k},$$
$$\cdot \quad \cdot \quad \cdot \quad \cdot$$
$$\tfrac{1}{2}(p-1)(m+v_1) - l_1 + S(r+c) = V_1,$$
$$\cdot \quad \cdot \quad \cdot \quad \cdot$$
$$\tfrac{1}{2}(p+1)(m+v_{p+1}) + S(r+c) = V_{p+1},$$
$$\cdot \quad \cdot \quad \cdot \quad \cdot$$



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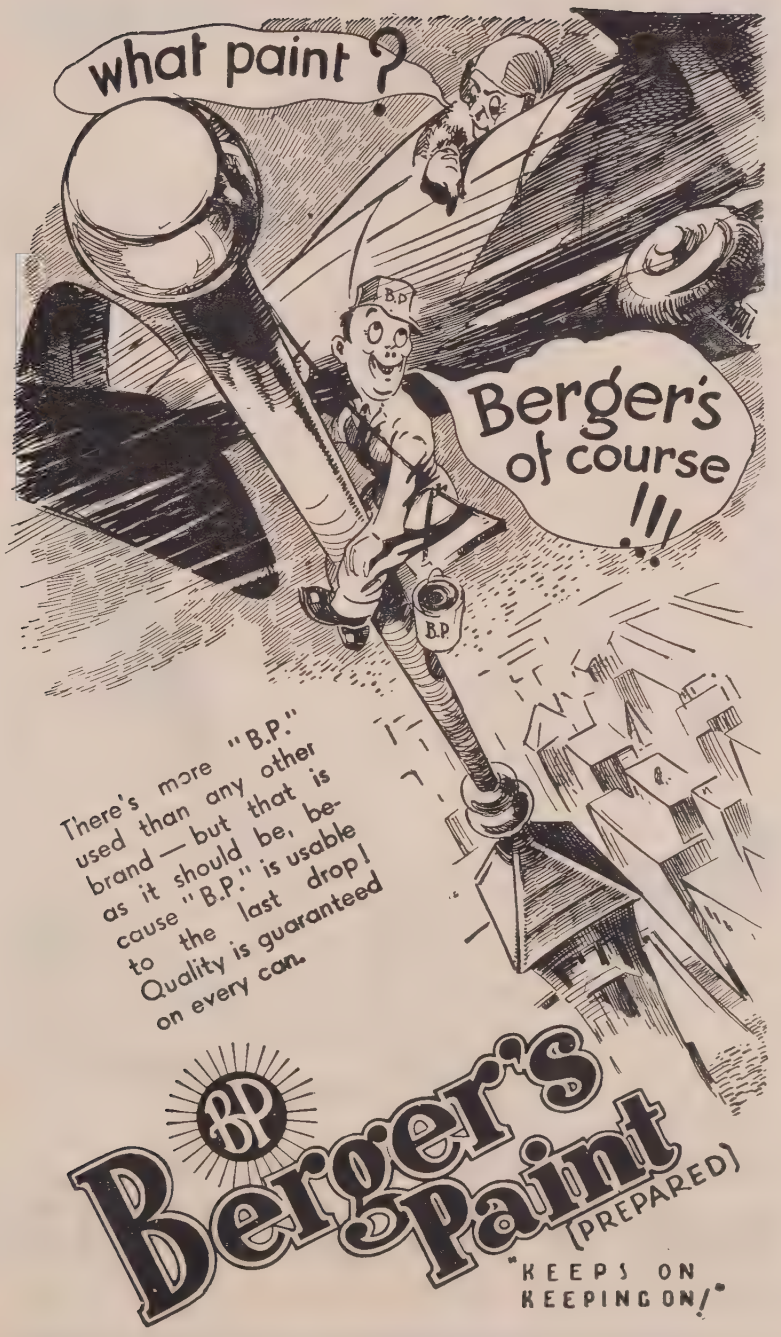
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$$\tfrac{1}{4}p^2(p-1)(p^2-1)m=p\{\tfrac{1}{2}(p-1)G+V_1+V_2+\ldots+V_p\}$$
$$-\tfrac{1}{2}(p+1)\{T_2+T_3+\ldots+T_{\frac{1}{2}(p+1)}\}$$

and v_1 from

$$\tfrac{1}{2}p(p-3)v_1=G+(pQ_1)-\tfrac{1}{2}p(p^2-1)m-\mathrm{S}(Q'),$$

where the summation is taken over the varieties associated with variety 1 in the first column of the first square, and the Q' are given by

$$Q'=\frac{2}{p(p-1)^2}\{G+(pQ_1)+(p-1)(pQ)-C_{11}\}.$$

v_2, v_3, ... are obtained from expressions similar to that of v_1, replacing (pQ_1) and C_{11} by the corresponding (pQ) and C and using the Q' functions of treatments from the appropriate column.

When v_1, ..., v_p have been found, the remaining v may be determined; thus

$$v_{p+1}=Q'_{p+1}-\frac{1}{p-1}v_1,$$
$$v_{2p+1}=Q'_{2p+1}-\frac{1}{p-1}v_1$$

and so on.

The l, r and c may now be obtained by substitution in the normal equations.

There are five types of varietal comparison:

(i) between varieties of the missing row: variance $\dfrac{4\sigma^2}{p-1}\left\{1+\dfrac{2(p-1)}{p(p-3)}\right\}$

(ii) between existing varieties which occur together in the same column of the square with the missing row: variance $4\sigma^2/(p-1)$

(iii) between existing varieties which occur in different columns of the square with the missing row: variance $\dfrac{4\sigma^2}{p-1}\left\{1+\dfrac{2}{p(p-1)(p-3)}\right\}$

(iv) between a variety of the missing row and existing varieties in the same column of the square with the missing row

(v) between a variety of the missing row and existing varieties not in the same column in the square with the missing row.

The variances of the last two types of comparison probably lie within the limits given by the variances of comparisons of types (i) and (iii).

Example 2.

Assume that the fourth row of the first square in Table I is missing. The new grand total is 1142 and the new totals for varieties 1 to 5, in order, are 17, 33, 45, 43 and 46, so that

$$m=\frac{1}{600}\{5(2\times 1142+184)-3(403+565)\}=15\cdot 7267.$$

Table IV shows the values of $-(5Q)$ for varieties 1 to 5 and the values of $-4(5Q)$ for the remaining varieties in sets as they occur together in the columns of the first square.

TABLE IV.

Variety.	$-(5Q)$	$-4(5Q)$			
1, 6, 11, 16, 21	155	1080	1200	596	556
2, 7, 12, 17, 22	197	864	928	996	720
3, 8, 13, 18, 23	205	1012	996	552	1016
4, 9, 14, 19, 24	233	884	1156	428	860
5, 10, 15, 20, 25	226	1040	1240	1048	908

Now

$$G+(5Q_1)-C_{12}=1142-155-32=955,$$

so that

$$Q'_6=\frac{1}{40}(955-1080)=-3\cdot125,$$

$$Q'_{11}=\frac{1}{40}(955-1200)=-6\cdot125,$$

$$Q'_{16}=\frac{1}{40}(955-596)=8\cdot975,$$

$$Q'_{21}=\frac{1}{40}(955-556)=9\cdot975,$$

whence

$$v_1=\frac{1}{5}\{G+(5Q_1)-60m-(Q'_6+Q'_{11}+Q'_{16}+Q'_{21})\}$$

$$=\frac{1}{5}(1142-155-943\cdot6+3\cdot125+6\cdot125-8\cdot975-9\cdot975)=6\cdot740$$

and, since,

$$\tfrac{1}{4}v_1=1\cdot685,$$

$$v_6=-3\cdot125-1\cdot685=-4\cdot810.$$

Similarly $v_{11}=-7\cdot810$, $v_{16}=7\cdot290$ and $v_{21}=8\cdot290$.

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TECHNICAL NOTES

PUCCINIA DISTINCTA McALP. AS THE CAUSE OF ENGLISH MARIGOLD RUST.

The purpose of this paper is to present experimental evidence that *Puccinia calendulæ* McAlp., the fungus causing rust of the English marigold (*Calendula officinalis*), is identical with *P. distincta* McAlp. from the English daisy (*Bellis perennis*), and with *P. cinerariæ* McAlp. from the garden cineraria (*Senecio cruentis*), and to unite these fungi under *P. distincta*, the first of the three to be described. Dr. G. H. Cunningham has already concluded, on morphological grounds, that *P. cinerariæ* McAlp. and *P. Allanii* G. H. Cunn. (from the New Zealand endemic *Senecio lagopus*) are identical with *P. distincta*. An examination of Queensland material confirms his observation of the identity of the cineraria and daisy rusts, and further shows that *P. calendulæ* is morphologically indistinguishable and must be considered a synonym of *P. distincta*.

The following field observations and experiments leave no doubt on the point.

The rust of calendula in Brisbane is often so severe that every plant in the garden is yellow with æcidia. *Bellis perennis* growing near such plants is invariably affected. The daisy has never been a very popular garden plant in Brisbane, but since the advent of the rust (first noticed on this species in 1907, and first appearing as an epiphytotic in 1934, at about the same time as the first outbreak of calendula rust), many nurserymen have ceased to raise seedlings for the market. The cineraria is less commonly attacked. Only four cases have come under personal observation, and on each occasion the plants have been growing in close association with heavily rusted English marigolds. Ordinarily, the cineraria remains free of the disease, even though calendulas in the same garden may be badly disfigured.

On August 7th, 1940, a number of leaves of cineraria with æcidia were received from a garden in Ascot, Brisbane. The æcidiospores were sown on young plants of calendula, and kept under bell-jars. On August 19th these seedlings had developed mature æcidia. Similar calendula plants were sown with æcidiospores from marigold, and developed æcidia at the same time.

Seedlings of *Bellis perennis* were sown with æcidiospores from calendula and from cineraria on August 9th, 1940, and covered with bell-jars. In each case infection was successful and mature æcidia first appeared on August 21st.

The infection of the cineraria with æcidiospores from the marigold was less successful. In 1939 a single sowing of spores on plants under bell-jars had failed. On July 24th, 1940, a single cineraria plant was given a dusting with spores. On August 9th there was still no sign of infection, so a heavily rusted calendula branch was placed beside the cineraria under the bell-jar, and the dusting of spores given to a number of plants growing in an open bed. On August 19th æcidia matured on the plant under the bell-jar, mostly near the margins of the leaves. Several uncovered plants that had been dusted with æcidiospores from calendula developed æcidia on August 26th, though only one was at all heavily infested. The æcidia were scattered over the leaves, mostly on the under surface. None appeared on plants that had not been heavily dusted with spores.

Lack of sufficient quantities of material from the English daisy prevented an adequate attempt to transfer the disease from this host to the cineraria. One plant only could be treated, and it developed only three æcidia. It is apparent that the cineraria is not very susceptible, as records of its rusting are few, and normally cinerarias are unaffected even where calendula rust is close by in the garden. In these experiments the numbers of æcidia were very few in proportion to the enormous numbers of spores dusted on the plants, whereas infection was very easily obtained on calendula and Bellis.

Summarised, the experimental results are: (1) "*Puccinia calendulæ*" from *Calendula officinalis* infects *Bellis perennis* readily, and the cineraria with apparent difficulty. (2) "*Puccinia cinerariæ*" from *Senecio cruentis* infects *Calendula officinalis* and *Bellis perennis* readily, and the cineraria with apparent difficulty. (3) "*Puccinia distincta*" from *Bellis perennis* infects *Calendula officinalis* readily, but lack of sufficient material prevented an adequate test of its effects on cineraria; three æcidia were produced in a small scale experiment with one plant.

The synonymy of *Puccinia distincta* McAlp. (1905) is *Æcidium calendulæ* McAlp. (1896), *Puccinia calendulæ* McAlp. (1903), *Puccinia cinerariæ* McAlp. (1906), and *Puccinia Allanii* G. H. Cunn. (1923). The earliest record of its occurrence in Australia was made when the æcidial stage on *Bellis perennis* was exhibited before the Royal Society of Victoria in 1880. Cooke (*Handbook of Aust. Fungi*, 1891) assigned it to *Æcidium bellidis* Thuem.; this is, however, a stage in the life cycle of a northern hemisphere species, *Puccinia obscura*, which has its II and III stages on various species of Luzula. *Puccinia distincta* McAlp. is confined to Australia and New Zealand, and as Cunningham has recorded it from a native host (*Senecio lagopus*) in New Zealand, he explains its remarkable occurrence on introduced species in these countries as a spread from a native plant to new hosts in New Zealand and thence to Australia. If it should ultimately prove that it is also native to Australia, it does not seem likely that that proof will come from Queensland, as all the evidence seems to point to its having reached this State from the south.

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PROTECTION OF CLOTH AGAINST MICROBIAL DETERIORATION—METHODS OF TESTING THE VALUE OF ANTISEPTICS*

In the course of an investigation into the value of 2 : 4 : 6 trichlorphenol for the preservation of cotton fabric, we have noted deficiencies in the published methods of testing this property. These are very artificial and, although providing some comparison between substances under particular conditions, they give little information as to likely performance " in the field " when free exposure will favour the evaporation of a volatile, and leaching of a soluble, antiseptic.

As examples of strictly laboratory methods, those used by Morris (1927), Schmitz (1931) and Hatfield (1935) might be noted. The last-named worker tested a number of substituted phenols, including 2 : 4 : 6 trichlorphenol, against wood-destroying fungi and found a high order of protection. Following essentially the same method with two organisms commonly found occurring on cloth (*Aspergillus niger* and *A. terreus*), we found good agreement with Hatfield's published figures for *Fomes annosus*. When, however, concentrations of the same order (0·01 to 0·2 per cent.) were applied to the cloth itself and the latter given more practical conditions of exposure, there was no appreciable protection. The need for simple " field " tests was therefore evident.

Methods.

Areas of cloth of known weight were sprayed with sufficient solution to give amounts of antiseptic equivalent to a range of acid trichlorphenol on a cloth weight basis. Even treatment was secured by means of a spray gun—care being taken to avoid splash and spraying beyond the margin. All pieces of cloth in any one series received approximately equal volumes of solution applied to both sides. After spraying the cloth was hung out to dry, wrapped and stored in a dry cupboard until tested.

Storage Tests under Humid Conditions.—Two simple methods have been used : (i) Pieces of cloth have been exposed in small dry shallow dishes within larger Petri dishes containing free water ; no more than one concentration was exposed within any closed vessel. (ii) Strips of cloth have been immersed to about one-fifth of their height in water within unstoppered test-tubes. In each case the pieces of cloth were examined both macroscopically and microscopically (low power) for mould growth and an assessment of amount was made in comparison with suitable controls.

For most experiments the first method has been used ; this gave an evenly humid atmosphere over the whole cloth surface and microscopic examination was easily effected without disturbing the cloth. The second method gave a range of saturation from the level of the water to near the top of the tube. In this method too, a measure could be obtained of deterioration in the strength of the fabric by determining the force necessary to break a ½-inch strip. So far as results go, the two methods are quite comparable, although the tube method is somewhat slower.

Results have shown that very much higher concentrations of both the trichlorphenol and its sodium salt are required in the " field " test than in the

* This note represents part of an investigation supported by Messrs. Timbrol Pty. Ltd.

method of Hatfield. Furthermore, the efficiency of the free acid is low compared with that of the sodium salt and in both cases there is a steady loss of protection with continued exposure ; this effect is also more rapid in the case of the free acid.

Persistence Against Leaching.

If an antiseptic is to be used outdoors its ability to withstand leaching by rain is of considerable importance. Iwanowski and Turski (1932) tested the trichlorphenols as wood preservatives against leaching obtained by overflowing the treated wood with water so as to provide, in a short time, the equivalent of a given number of leaching years. With cloth we have used the following simple method :

Areas of treated and control materials have been cut so as to fit the bottom of 9 cm. Buchner funnels. A given head of distilled water has been kept over the cloth for regular intervals and the water then allowed to run through the cloth and replaced by the next volume. By this means it is easily possible to subject the cloth to the equivalent of 180 inches of rain in one month. From time to time small pieces of cloth are cut from the discs, set up in moist chambers and the degree of persistence determined by ability to withstand moulding compared with that of suitable controls. Because of the removal of soluble filler materials by leaching the development of organisms tends to be slow and relatively scanty, even in unsprayed controls, and in order to speed up the test and facilitate differentiation, the pieces of cloth have been saturated with 1 per cent. sucrose before incubation. It has been found that the addition of sucrose to protected cloth did not break down its resistance.

Our results with sodium salts of both trichlorphenol and salicylanilide (a substance widely used for cloth protection and included for comparison) showed little resistance to leaching when subjected to this test.

Persistence Against Evaporation.

It seems likely that the volatility of the free acid of trichlorphenol and slow hydrolysis of the sodium salt in air, account for the difference between the laboratory test of Hatfield and the practical tests described above. This point was tested by exposing sprayed cloth in front of a fan for seven days, and comparing subsequent protection in a humid atmosphere with that of cloth of the same spraying but kept in a closed container. Both treatments were heavily inoculated with spores of *A. niger* and kept in stoppered tubes. The cloth exposed to the fan, whether treated with the acid or the sodium salt, showed heavy growth at from 0·5 to 1 per cent. (the range tested) whereas in both treatments the cloth kept in containers during the storage period gave full protection as low as 0·5 per cent.

Determination of "Killing" Concentration.

There is a further point in Hatfield's technique that seems to call for some comment. This worker determined the " killing " concentration by removing inoculum blocks which had been in contact with the antiseptic-treated agar on to fresh slopes of malt agar. Failure to grow in this transplant was taken as evidence of death at that concentration. It seems likely that such prevention of growth might, at least for some concentrations, be due to persistent inhibition by reason of substance carried over in the inoculum block diffusing into the fresh medium. Such an effect would explain our experience.

0·01 per cent. TCP inhibited growth and the inoculum removed to a fresh slope failed to grow (=killing concentration according to Hatfield) ; but fresh spores also failed to grow on this slope. The same inoculum removed, allowed to soak in sterile water and then placed on a fresh slope, showed abundant growth. A true killing effect was demonstrated with higher concentrations by failure of washed inoculum to grow on a slope which was yet able to support full development of viable spores.

It seems evident that if information as to killing concentration is required, the method hitherto used needs to be modified along the lines here indicated.

Summary.

Simple tests are described enabling an assessment of the value of antiseptics for protection of fabrics under practical conditions, taking account of storage and outdoor exposure problems.

The possibility of marked discrepancy between such tests and strictly laboratory tests is emphasised and attention drawn to an apparent fallacy in Hatfield's method of determining " killing " concentration.

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University of Sydney. J. M. VINCENT.

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CALCULATION OF ACCUMULATED TEMPERATURE.

The complete paper on this subject may be obtained, on application, from the Meteorological Office, Melbourne.

The metabolism of a plant may be regarded as a complicated set of chemical reactions subjected to several influences, of which temperature is the most important. The total growth of a plant from the sowing of the seed to the ripening of the fruit depends upon the " total effective temperature " to which the plant has been subjected.

By an unusual method the author has obtained a simple expression which enables accumulated temperature to be calculated from a knowledge of only mean maximum and mean minimum temperatures and the determined base temperature. As these climatological elements are readily available, the formula, if reliable, would be very convenient in use. The method itself may have other applications and may also suggest means of attacking similar problems.

The fundamental formula is :

$$\int AT=(\overline{T}-T_0)f+\frac{1}{\pi}\sqrt{(T_2-T_0)(T_0-T_1)}$$

where $\int AT$=day degrees, $\overline{T}$=average temperature of the day, T_2=maximum temperature, T_1=minimum temperature, and T_0=chosen base temperature. The radical must always be taken with the positive sign. The fraction f is best calculated from the formula

$$\tan f\ \pi/2=\sqrt{(T_2-T_0)/(T_0-T_1)}$$

The angle so found will be in degrees : f is then found by dividing this angle by 90.

The formula proposed is intended only to give a useful approximation to the actual accumulated temperatures, or to give results which are intercomparable with accumulated temperatures similarly derived. The assumption on which the formula is based is that for purposes of calculating sufficiently approximate monthly accumulated temperatures, it is only necessary to consider one simple sine distribution of temperature having the mean maximum and mean minimum monthly temperatures as extreme values. The variation from day to day of the maximum and minimum, the range of temperature between them, and the form of the diurnal distribution require individual treatment of each day's values for an accurate determination of the monthly accumulated temperature.

This is pointed out in the complete paper, but the opinion is expressed that the theoretical value will be sufficiently accurate (probably only for certain classes of climate). A check on the reliability of the formula and its application to different classes of climates seems required.

The concept of accumulated temperature and the method of calculating the same may have applications in indicating the broad temperature zones in Australia within which the establishment of new crops (the temperature requirements of which are known from experience elsewhere) could be undertaken, provided other factors, e.g. moisture and soil conditions, were favourable.

The complete paper shows that the temperature comparisons of Giza (Egypt) and Bourke (New South Wales) clearly indicate that temperature would not be a factor limiting the successful establishment of the date palm at Bourke.

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The Australian Institute of Agricultural Science

MEETINGS OF COUNCIL

At the meeting of Council held in the Department of Agriculture, Melbourne, on 5th December, 1940, the following were appointed office-bearers of the Institute: Hon. Secretary, Mr. A. J. Vasey; Assist. Hon. Secretary, Mr. R. D. Croll; Hon. Treasurer, Mr. R. L. Twentyman; Editor of Journal, Dr. H. J. Hynes; Business Manager of Journal, Dr. N. S. Noble. The financial statement showed a balance at bank of £249 16s. 9d. as at 6th December, 1940. It was reported that £100 of the Institute's funds were to be invested in the current War Loan.

At the January meeting of Council the following were appointed members of the Publications Committee: Dr. R. J. Noble (chairman), Dr. H. J. Hynes, Dr. N. S. Noble and Mr. H. J. Geddes. Mr. R. C. Rossiter was elected to corporate membership. The question of a special Qualifications Committee to deal with applications for admission to membership was discussed, and the matter deferred pending receival of comments from all Branches.

MEETINGS OF BRANCHES

Canberra Branch.

On 5th February, 1941, a general meeting of the Canberra Branch was addressed by Mr. J. K. Taylor, Senior Research Officer, Division of Soils, C.S.I.R., on "The Conservation of the Land and the Farmer in America". He outlined the history of American agriculture from 1914 onwards. Soil erosion was brought home to the people of the eastern States by the severe duststorms from Kansas and Oklahoma during the 1934 drought. Since then, hundreds of thousands of people had abandoned their farms and migrated to Oregon and California. The large proportion of land farmed on shares was an important factor in soil deterioration. Numerous government agencies were set up to deal with various aspects of these problems, and some confusion resulted. To coordinate their activities, the Office of Land Use Co-ordination was formed.

The Soil Conservation Service subdivided U.S.A. into ten regions, each with a complete staff of soil surveyors, agronomists, engineers, foresters, etc. Each region was further subdivided into project districts with a community campaign of attack. The Agricultural Adjustment Administration paid farmers not to grow certain crops, but in return demanded a large say in the handling of the farm. The speaker concluded by stating that although Australia had not reached the position of the U.S.A., if no preventive measures were undertaken, the situation in twenty years' time would be similar here.

New South Wales Branch.

At the November meeting, held at Science House on the 22nd of the month, Mr. H. B. Parry, Lecturer in Veterinary Medicine, University of Sydney, gave an address on "Current Problems of Animal Production and a Review of the American Livestock Industry". The address was well illustrated by many beautiful Kodachrome slides.

The livestock industry in the United States of America is based on two main geographical regions. The more arid grazing areas of the west and south-west are the raising country, while in the corn belt States the feeder stock are fattened on maize.

Beef cattle are raised almost exclusively in the range country of the west and south-west and move north-eastwards towards the corn belt for finishing, although some are grazed out on summer grass in Kansas. The corn belt is mainly concerned with converting maize into beef and pork, range steers being fattened in the feed lots during the winter months. The pig industry is almost confined to the corn belt States.

The sheep industry is based in the main on Rambouillet ewes mated to produce a feeder lamb, which is sold in the autumn and fattened in Colorado on wheat and beet pulp from the local sugar beet industry. Some are shipped into the corn belt. The sheep country lies farther west than the cattle country, relying on summer grazings in the Rocky Mountains and on the Edwards Plateau of Texas.

The dairy industry may be divided into three sections, the Atlantic Seaboard, the Middle West and the Pacific Coast. The Atlantic section is based on natural pastures with supplementary feeding in the winter. In the middle west dairying fits into the scheme of

mixed farming, with winter housing and feeding depending on maize silage and concentrates. On the Pacific Coast in Oregon the industry relies on natural pasture, while in Southern California lucerne hay, grown under irrigation with concentrates, is depended upon.

After dealing with the more general feeding problems and vitamin deficiencies, the lecturer stated that of the recent work on minerals, that on three or four elements was of particular interest. The most spectacular work has been done on selenium. This occurs in concentrations of about ten parts per million in certain shales of Upper Cretaceous age in South Dakota and Wyoming, where alkali disease has long been known. The role of selenium in the etiology of this disease has been suspected for several years, but the part played by " converter " plants has only just been realised. Certain plants, in particular *Astragalus racemosus, Aster multiflorus* and *Stanleyi bipinnata*, contain very high concentrations of selenium, even when the soil is low in this element, and are highly toxic. These plants convert the selenium into an organic form, which is then available to grasses and herbage plants which do not absorb selenium in the organic form. Fluorine has caused trouble in a number of areas and the mottling of teeth is common in certain districts.

At the sixth annual general meeting, held at Science House on 14th February, 1941, the following office-bearers were elected: President, R. N. McCulloch; Vice-President, A. W. S. Moodie; Hon. Secretary, H. P. Brown (re-elected); Treasurer, L. Wilson (re-elected); Committee of Management, F. T. Bowman, F. L. Milthorpe and W. W. Jones.

The retiring President, Mr. A. W. S. Moodie, delivered the presidential address on " Agricultural Efficiency in Relation to Production Costs ", which will be published in the June issue of this Journal.

Victorian Branch.

On 29th November, 1940, Mr. S. Fish, Biologist of the Victorian Department of Agriculture, addressed members on the subject " Plant Pathology and Methods Developed for Plant Disease Control ". Mr. Fish reviewed the development and trends of plant pathology, and urged the necessity for plant pathologists, in their approach on plant disease problems, to establish a more normal balance between plant physiology on the one hand and mycology and related subjects on the other. In the discussion of the principles of plant disease control, mention was made of how the available methods had been utilised in connection with Victorian plant disease problems, and a wide range of lantern slides suitably illustrated the points made. It was finally indicated that the development of future methods of disease control should be the inevitable result of the formulation of a system of knowledge of plants and their diseases based on experimentally established facts.

South Australian Branch.

A meeting was held on 12th December, 1940, to discuss the question of " Diversification of Farming ". The President, Dr. A. R. Callaghan, gave an opening talk on diversification, the need and desirability for it to be included in any programme for stabilising the farming community. He elaborated concrete proposals for the inclusion of payable sidelines as an integral part of farm development, whether they be pig-raising, dairying, poultry-raising or combinations of them. The desirability of using permanently employed labour on farms instead of the casual, floating type at harvest or intermittently through the year was insisted on as an essential feature of diversification. In discussion, some members felt that such schemes were a solution on the short, but not on the long run. It was also pointed out that soil erosion was a potent influence in forcing consideration of modifications of farm practice equally with the present marketing situation. No doubt existed of the need for a thoroughgoing examination of all aspects of rural economics in Australia.

Western Australian Branch.

At the December, 1940, meeting, Mr. K. R. Norris, an officer of the C.S.I.R., addressed a well attended meeting on " The Red-Legged Earth Mite ". The lecture was mainly an account of research performed by the speaker during the past four years to find whether the earth mite (*Halotydeus destructor*) could be controlled by cultural means. An account was given of various experiments performed on the æstivating eggs of the mite to find whether these were vulnerable at any stage. Other work described included investigations into the importance of weeds in relation to the mite problem, the effect of various fertilisers on the severity of mite attack, a search for resistant strains of subterranean clover, and the comparison of the effectiveness of various insecticides. An experiment to measure the reduction in yield of the pastures due to the mite gave very clear-cut evidence that mite attack produced a reduction in foliage yield and seed yield, and produced earlier wilting. The possibilities of biological control were also being investigated by the C.S.I.R.

Queensland Branch.

On 29th November, 1940, the President welcomed Mr. W. C. Skelsey (Editor, " Queensland Country Life ") as guest speaker to address a meeting of the Branch on the subject of " Agricultural Organisation for Wartime Conditions ".

Mr. Skelsey expressed the opinion that Australia was deserving of censure for not having taken steps to visualise and supply a greater proportion of Britain's food requirements. Nazi occupation of European countries had cut off supplies to Britain which in 1938 were worth £77,000,000. Of these, £34,000,000 worth represented dairy produce and £22,000,000 bacon, ham and poultry products—commodities which Australia could and should supply. But Australia's primary industries were not yet organised on a war footing. It would appear that primary production could be organised on a basis similar to other essential wartime industries. Advocacy of increased production incurred certain post-war risks, but actually there was little risk if we studied Britain's needs and gave due regard to the fact that the cattle, pigs and poultry in European countries, which formerly sent large supplies to Britain, had been slaughtered to provide meat for the Nazis.

Dairying headed the list of industries which warranted special attention in a wartime drive. We could produce a lot more butter, cheese and dried milk with the confidence that it was required by the British people during the war and would be useful afterwards in the battle against substitutes. Production would be expanded by an improvement in feeding practices, and through an increase in butter-fat production per cow. There was practically no limit to the quantities of pig meats Britain was prepared to take. Queensland should keep on expanding its fat lamb industry, and further stimulation of the beef cattle industry was desirable.

Substantial and rapid expansion of the livestock industries was bound up with a more persistent effort to get producers interested in fodder conservation, water conservation, production of fodder crops and sown pastures of lucerne and artificial grasses and clovers for grazing. Stressing fodder conservation, Mr. Skelsey said that lack of an adequate fodder reserve on farms was a serious limiting factor with respect to all animal industries. We had accumulated sufficient knowledge to maintain reasonable stability of production in spite of a few months' dry weather, and this knowledge should be applied. Finally, there should be a greater application of science to the problems of primary production to meet more effectively the competition of substitutes and to reduce the cost of production in all primary industries by the elimination of preventible waste.

Tasmanian Branch.

The fifth annual general meeting of the Tasmanian Branch was held in Hobart on Friday, 20th December, 1940. The balance sheet showed a very satisfactory position. It was agreed, following upon a suggestion made by the relieving president, that the officers for the coming year should be elected from northern members, and the following officers were duly nominated and elected: President, J. T. Armstrong; Vice-President, R. A. Sherwin; Secretary-Treasurer, H. R. Dickinson; Committee, E. F. Fricke and D. Martin; Sub-Editor, Miss Gray; Auditor, H. V. Rees.

Mr. Sherwin, in his presidential address, dwelt upon the effects of war on agriculture, with particular reference to Tasmania. He pointed out that everything possible should be done to ensure that the primary producers could carry on, and suggested that the Government could assist in this in acquiring production. It was also pointed out that the post-war period would be difficult and the problem of contracting markets would probably have to be faced.

Current Notes and News

Irrigation Extension School, Griffith.

This school was held at the C.S.I.R. Irrigation Research Station, Griffith, during the week beginning 25th November, 1940. It was conducted under the ægis of the Irrigation Research Extension Committee, as part of the committee's programme of extension work on the Murrumbidgee Irrigation Areas. The immediate object of the school was to bring the results of recent research on soils and irrigation before extension workers and to discuss the application of this information to farm practice on the M.I.A.

The school was attended by about 80 members, including research, extension and administrative officers of the four bodies represented in the Irrigation Research Extension Committee, namely the N.S.W. Water Conservation and Irrigation Commission, the Rural

Bank of N.S.W., the N.S.W. Department of Agriculture and the C.S.I.R. Irrigation Research Station, Griffith. Settlers were represented by members of the M.I.A. Co-operatives Executive Committee and the advisory committee of the Griffith Research Station. Others who attended included officers of the Victorian State Rivers and Water Supply Commission, the Victorian Department of Agriculture, the N.S.W. Department of Education and the C.S.I.R. Divisions of Soils and Plant Industry and Commonwealth Research Station, Merbein.

The school comprised eight sessions, each made up of an hour's lecture, followed by about two hours' discussion and demonstrations. The subjects and lecturers were as follows :

" Soils of the M.I.A.", J. K. Taylor, C.S.I.R. Division of Soils.
" Soil Moisture ", E. S. West, C.S.I.R. Griffith Research Station.
" Soil Structure ", A. Howard, C.S.I.R. Griffith Research Station.
" Irrigation Methods ", R. R. Pennefather, C.S.I.R. Griffith Research Station.
" Waterlogging and Seepage ", H. N. England, N.S.W. Water Conservation and Irrigation Commission.
" Extension Principles and Methods ", C. C. Crane, N.S.W. Department of Agriculture.
" The Extension Worker in a Changing World ", J. G. Crawford, Rural Bank of N.S.W.

One afternoon was spent in field demonstrations, and the final session was devoted to a review and discussion on the general subject matter of the school, led by Professor J. A. Prescott.

The appointment of discussion leaders for each session proved successful in stimulating fruitful discussion along important lines. Recorders were appointed for each session, and the proceedings are now being prepared for publication.

A feature of the school was the emphasis placed on the need to study the soil as it exists *in situ*, and not only as a material collected below a 2 mm. sieve. Soil structure was shown to be of great importance in research and farm practice on the M.I.A., and formed a recurrent theme in discussions on soil, water and air relationships, root development and plant nutrition, and irrigation, soil and general farm management.

At a future time, it is proposed to hold a second school dealing with plant nutrition and the chief orchard crops on the M.I.A.

Book Review

WHEAT AND FLOUR QUALITY, by C. O. SWANSON, Ph.D.

(227 *pp. Mimeoprint, Burgess Publishing Company, Minneapolis, Minnesota,* 1938. *Revised edition.* 3.00 *dollars.*)

Dr. C. O. Swanson, Professor and Head of the Department of Milling Industry at the Kansas State College, Manhattan, has published his book " Wheat and Flour Quality " primarily as a lecture manual for students, but has kept in mind the requirements of others interested in the subject. He has brought together the information available on almost all wheat and flour problems, and has compiled a mass of data of interest to persons associated with the various phases of the wheat and allied industries.

The material is presented in a succinct literary style, clearly expressed so that, whilst it is very valuable to the research student and highly trained laboratory technician, it can also be interpreted by the less skilled worker.

The text covers a comprehensive field ; the meaning of the term " quality " as applied to wheat and flour, and the significance of chemical determinations are fully discussed. Chapters are included on the proteins, carbohydrates and enzymes, and the influence of environment on wheat quality is considered in some detail. Storage of grain and the physical aspects of cereal chemistry receive full consideration.

Wherever possible, tabulated results have been provided from which the text can be readily interpreted ; a limited number of illustrations is also included. The author has quoted freely from other workers, and at the end of each chapter is a comprehensive bibliography. Whilst the text refers chiefly to wheat and flour quality under American conditions, the subject matter is so clearly presented that its application to Australian conditions is readily seen.

The inclusion of detailed descriptions of some of the mechanical dough testing devices of Continental origin would have made the volume more complete, but in its present form it is a particularly valuable reference book.

J. R. Fisher.

Personal Notes

Professor S. M. Wadham has been elected President of the Professorial Board, Melbourne University.

Mr. F. Penman, Research Chemist of the Department of Agriculture, has been seconded to the Department of Munitions, and is supervising the production of explosives at one of the factories. Messrs. K. D. Nicholls (Munitions Supply Laboratory) and A. W. Stewart (Explosives Factory) are also engaged in chemical work in the Department of Munitions.

Mr. H. L. Hore, Inspector of Agriculture, has been appointed a member of the Soil Conservation Board of Victoria, representing the Department of Agriculture.

Mr. R. E. P. Dwyer, Economic Botanist, Mandated Territory of New Guinea, returned to Rabaul in December last after six months' leave, much of which was spent in a series of investigations at the Botany School, University of Sydney.

Mr. E. A. Cornish has been appointed Senior Biometrical Officer in the C.S.I.R., with headquarters in Melbourne.

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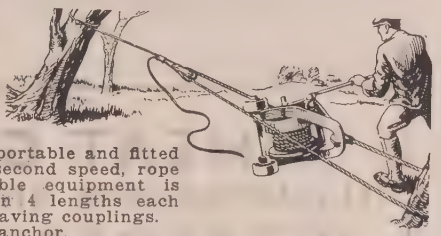

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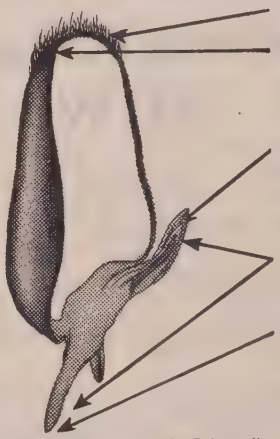

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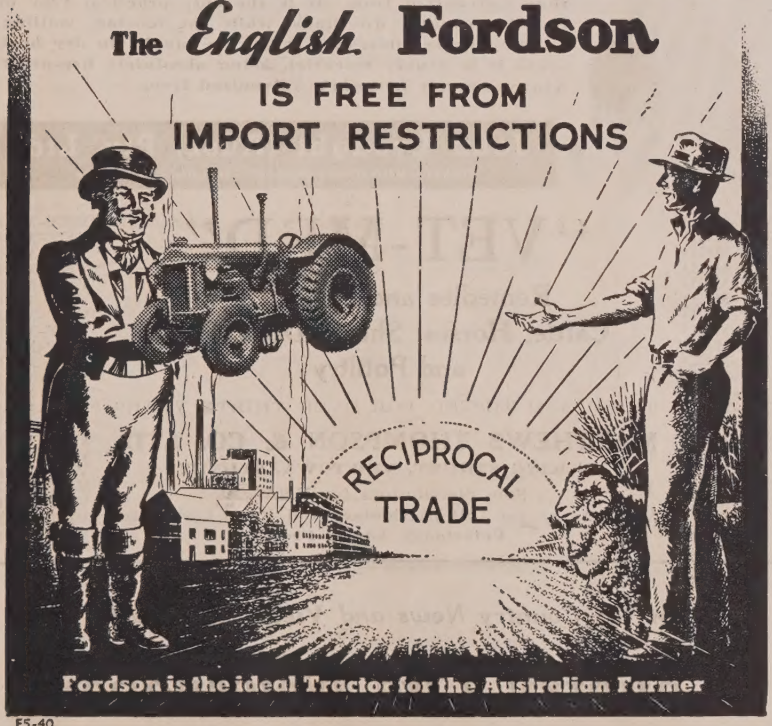

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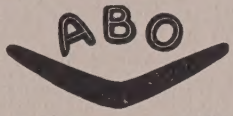

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